cessive epochs, they have fallen enormously in the later years for diseases incident to the local climate.

*1898.*—Among the employees of the company there was no sickness of an epidemic character; the sanitary conditions were satisfactory.

On the Isthmus generally, a light epidemic of influenza prevailed during the months of January and February, but no yellow fever or other sickness of an epidemic form appeared.

*1899.*—Among the employees of the company there was a single case of yellow fever, contracted at La Boca, in November by a Frenchman recently arrived and employed on the harbor works. He recovered. There was no other sickness of an epidemic form among the employees of the company, and the sanitary condition was satisfactory.

In the City of Panama, between May and the middle of December, there were about 139 cases of yellow fever. Its victims were chiefly foreign sailors arriving in the bay and Colombian soldiers from the interior.

In June and July a rather severe epidemic of influenza occurred. In September a short epidemic of measles caused some deaths. The City of Colon appeared to be proof against yellow fever.

*1900.*—Among the employees of the company a single case of yellow fever occurred, terminating in recovery, and there was no other sickness of an epidemic form. The sanitary condition was satisfactory, notwithstanding the rather high death rate caused by a larger number than usual of deaths from chronic diseases of a general type.

On the Isthmus, generally, yellow fever, which had disappeared after the middle of December, returned in March. Between that date and September 10, about 138 cases occurred in Panama, of which 128 were among the Colombian soldiers from the interior. There was no other sickness of an epidemic form. The City of Colon escaped yellow fever.

*1901.*—No epidemic appeared among the employees of the company, and the sanitary condition was very satisfactory.

On the Isthmus, generally, yellow fever, of which no case had been reported since September 10, 1900, was again imported in January, 1901, by a priest and a sister of charity coming from Buenaventura. It was communicated to a sister of the orphan asylum of the central hospital and then to the superior. The latter alone recovered. These four were the only cases in January, 1901; and since then up to the present month (March, 1902) there has been no return of the disease.

In April, 1901, a serious epidemic of smallpox appeared in Panama and still continues. The employees of the company have suffered very little, a result which should be attributed to the numerous vaccinations which have been made.

The City of Colon appears always to escape these epidemics.

*General conclusions.*—Considering the average figures for the last four years, I find that with a personnel of 2275 the percentage of disease has been 29.65, and the mortality 2.35 per cent. These figures do not exceed those on large works in any country.

It should, however, be added that this personnel has been long on the Isthmus and is well acclimated; I may even say extremely so, since 91 per cent of the total death rate is due to chronic organic diseases common to all countries, leaving only 9 per cent of it chargeable to the diseases of the local climate.

The classified employees, which constitute about 8 per cent of the entire force, are represented in the total death rate by 5.70 per cent, while the laborers are represented by 94.30 per cent. The mortality in the latter class is therefore the greater.

Among infectious diseases on the Isthmus yellow fever is undoubtedly the most to be feared by unacclimated persons of the white race. During the two recent epidemics of yellow fever—the first from May to December 15, 1899, and the second from March to September 10, 1900—only two cases appeared among the personnel of the company. Both were French, one a workman on the wharf at La Boca who had been only a few days in the country, and the other the head nurse of the company's hospital who had held this position for two years. To these should be added the superior of the sisters at the hospital, attacked in January, 1901, after three or four months of residence, one of the four solitary cases of this month just mentioned. These three cases recovered. I attribute the last two cases to infection proceeding from the foreign hospital, which received a large number of the 261 cases occurring in the different epidemics and which, by its too close proximity, is a menace to the hospital of the company. The latter offers satisfactory sanitary conditions.

I have mentioned in former reports the disappearance of yellow fever from the Isthmus from the year 1892 to the year 1897. This would lead to the belief that the disease is in no wise necessarily endemic. In 1897, indeed, between the beginning of March and the beginning of August there were about 70 cases, as well at Panama as on a portion of the line of the canal, but no case occurred at Colon.

I will remark that the City of Colon, which up to about the years 1891–92, was a terrain than which nothing could be better for yellow fever—reputed more dangerous than the City of Panama—has since that time remained free from any infectious disease and has escaped the yellow fever epidemics of 1897, 1899, and 1900. This is evidently due to the sanitary works which have been executed, the filling up of the many little swamps and the cleaning of streets which before were veritable sewers. By these improvements the City of Colon has been considerably freed from the swarms of mosquitoes which rendered life insupportable.

Might not a like result be secured for the City of Panama (1) by a good supply of pure water, (2) by drains to conduct sewerage to the sea, to which its situation and conformation are easily adapted, and (3) by watering the streets daily in the dry season, and by cleaning them daily throughout the entire year. Now they are in a repulsive condition of filth. These three improvements, which I consider fundamental and essential, are now wholly neglected.

There should also be instituted an effective quarantine service for vessels arriving in the harbor, for beyond all doubt the epidemics of 1897, 1899, and 1900, and the few cases which occurred in January, 1901, were due to importations, in one instance from the Atlantic and in three instances from the Pacific.

I do not expect by these measures to remove completely from Panama its character as a terrain favorable for the propagation of yellow fever; but certainly, if thoroughly applied, they would exclude some epidemics and render a residence on the Isthmus less dangerous for unacclimated persons of the white race.

The important works executed from one end to the other of the line of the canal have also done much to improve the sanitary conditions existing on the Isthmus.

## MEAN BAROMETRIC PRESSURE AT SEA LEVEL ON THE AMERICAN ISTHMUS.

By GENERAL HENRY L. ABBOT, dated Cambridge, January 27, 1903.

The series of meteorological observations made on the Isthmus by the new Panama Canal company now includes a continuous hourly record of barometric pressure at Alhajuela on the upper Chagres River since June, 1899, lacking only a single month, May, 1902. Unfortunately, an undetermined error in the reading of the barograph prevents this series from being available in connection with the numerous observations made by the Weather Bureau in the West Indies, and published in the MONTHLY WEATHER REVIEW; and it has, therefore, seemed to me to be desirable to determine it with all possible precision. As there are no facilities for a direct comparison with a standard barometer, resort must be had to indirect methods. The height of the instrument above mean tide (148 feet) is accurately known, together with the simultaneous hourly temperatures at the station. If then, the true reading of the barometer at mean sea level in this vicinity can be determined, the difference between this quantity and the mean of the recorded readings of the instrument reduced to sea level should furnish the desired instrumental correction.

The MONTHLY WEATHER REVIEW supplies all needed facilities for determining the true barometric reading at mean sea level in this region. It has furnished in full for the years 1899 and 1900 the hourly barometric pressure and corresponding air temperatures at various stations in the West Indies, of which the heights above sea level are recorded. Since hourly observations eliminate horary variations in pressure, and full annual series eliminate monthly variations, observations so long continued in a region of extraordinary uniformity of pressure can certainly be trusted to essentially eliminate abnormal variations, together with any small instrumental errors of instruments so carefully adjusted as those of the Weather Bureau. The probable error of a reading at mean sea level, thus deduced, should be insignificant. It remains to select the stations.

To eliminate gravity variations, the stations should lie as nearly as possible on the same parallel of latitude as Alhajuela. Four fulfill this condition, and all of them, fortunately, are but little elevated above the sea, thus favoring the needed reductions. Two of these stations are Willemstad, Curaçao, and Bridgetown, Barbados, at each of which two full years are available. At Port of Spain, intermediate between the two, the records cover ten months in 1899 and nine months in 1900. To utilize the nineteen available months, it is only needful to correct the error due to the missing months by interpolations, which may be found by adding to the partial annual means the difference between the mean for the corresponding months in the four complete years and their true annual means, and then adding to this for each missing month its departure on the 4-year curve. The fourth station is Colon, where, unfortu-

nately, only eight months are available in 1898 and 1899. No satisfactory method for interpolation for the missing months, where no annual mean is on record, has suggested itself, but the figures actually observed are given for comparison in Table 1 which sets forth the results of the study. To determine the weight which should be accorded to the final result, its probable error has been computed by applying the noted mean correction to each of the sixty-seven months, and proceeding in the usual manner. The probable error is found to be 0.0023 inches. It would appear, therefore, that 29.906 inches may be adopted with confidence as the desired mean reading at the level of mean tide in the region in question.

TABLE 1.—*Barometric pressure in inches, reduced to mean sea level.*

| Month. | Bridgetown, 2 years. | Willemstad, 2 years. | Mean, 4 years. | Port of Spain, 19 months. | Mean, 3 stations. | Monthly corrections. | Colon, 8 months. |
|---|---|---|---|---|---|---|---|
| January | 29.943 | 29.906 | 29.924 | 29.893 | 29.916 | —0.010 | 29.842 |
| February | 29.990 | 29.933 | 29.962 | 29.937 | 29.953 | —0.047 | 29.865 |
| March | 29.966 | 29.914 | 29.940 | 29.917 | 29.933 | —0.027 | 29.874 |
| April | 29.948 | 29.873 | 29.910 | 29.902 | 29.907 | —0.001 | 29.851 |
| May | 29.960 | 29.885 | 29.923 | 29.916 | 29.921 | —0.015 | 29.857 |
| June | 29.964 | 29.892 | 29.929 | 29.932 | 29.930 | —0.024 | ..... |
| July | 29.938 | 29.888 | 29.913 | 29.903 | 29.910 | —0.004 | ..... |
| August | 29.926 | 29.871 | 29.898 | 29.904 | 29.907 | —0.001 | ..... |
| September | 29.923 | 29.860 | 29.892 | 29.903 | 29.895 | +0.011 | ..... |
| October | 29.878 | 29.824 | 29.851 | 29.949 | 29.850 | +0.056 | 29.836 |
| November | 29.879 | 29.829 | 29.854 | 29.853 | 29.854 | +0.052 | 29.868 |
| December | 29.913 | 29.882 | 29.897 | 29.915 | 29.903 | +0.003 | 29.932 |
| Annual mean | 29.936 | 29.880 | 29.908 | 29.902 | 29.906 | ..... | 29.866 |

NOTE.—The departure is subtracted from, or the correction is added to, the monthly reading in order to produce the annual mean.—ED.

It remains to determine the corresponding reading of the barograph belonging to the new Panama Canal company, which is given in Table 2 the missing reading for May, 1902, being interpolated from the curve of corrections in the manner indicated above.

TABLE 2.—*Barograph readings in millimeters at Alhajuela, reduced to mean sea level.*

| Month. | 1899. | 1900. | 1901. | 1902. | Mean. | Monthly corrections. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Millimeters. | Inches. |
| January | ..... | 764.38 | 764.59 | 763.15 | 764.04 | —0.53 | —0.021 |
| February | ..... | 764.46 | 763.96 | 763.95 | 764.11 | —0.60 | —0.024 |
| March | ..... | 764.06 | 763.57 | 762.98 | 763.54 | —0.03 | —0.001 |
| April | ..... | 763.64 | 762.83 | 762.48 | 762.98 | +0.53 | +0.021 |
| May | ..... | 763.63 | 763.20 | *762.65* | 763.16 | +0.35 | +0.014 |
| June | ..... | 764.06 | 763.16 | 762.09 | 763.10 | +0.41 | +0.016 |
| July | 763.63 | 764.53 | 763.15 | 762.74 | 763.51 | 0.00 | 0.000 |
| August | 763.07 | 764.29 | 763.28 | 762.51 | 763.29 | +0.22 | +0.009 |
| September | 763.64 | 764.70 | 763.58 | 762.88 | 763.70 | —0.19 | —0.007 |
| October | 764.28 | 764.17 | 762.88 | 763.64 | 763.74 | —0.23 | —0.009 |
| November | 763.27 | 764.21 | 763.94 | 763.60 | 763.83 | —0.32 | —0.013 |
| December | 763.73 | 764.12 | 762.25 | 763.35 | 763.16 | +0.35 | +0.014 |
| Annual mean | 763.60 | 764.21 | 763.37 | 763.00 | 763.51 | ..... | ..... |

NOTE.—The italic figures, May, 1902, indicate interpolation.—ED.

The mean reading deduced in the table is thus 763.51 millimeters. The mean of the three complete years is 763.53 millimeters, and the grand mean of all the months observed is 763.54 millimeters, all reduced to mean sea level. The desired correction to the barograph is, therefore, —3.90 millimeters.[1] Applying it to each of the forty-one months for which we have mean readings, corrected for monthly variation by the local curve of corrections, we have for the reading at mean sea level $759.61 \pm 0.062$, or $29.904 \pm 0.002$ inches. It would seem, therefore, that confidence may be accorded to this estimate of the desired correction. It may be added that as the reduction to the sea level only ranges from +3.74 to +3.78 millimeters, according to the observed readings and corresponding temperatures, the two corrections nearly balance each other, and the recorded reading of the barograph may be adopted as that at sea level with a trifling error, not exceeding 0.006 of an inch.

Incidentally, this study has thrown light on the question of mean monthly variation of barometric pressure. Table 3 recapitulates the above corrections for each month:

[1] See the note by Professor Bigelow on a subsequent page.—ED.

TABLE 3.—*Monthly variation in barometric pressure at sea level, in inches.*

| Month. | The three stations long. 65°. | Alhajuela long. 80°. | Mean correction. |
|---|---|---|---|
| January | —0.010 | —0.021 | —0.015 |
| February | —0.047 | —0.024 | —0.035 |
| March | —0.027 | —0.001 | —0.014 |
| April | —0.001 | +0.021 | +0.010 |
| May | —0.015 | +0.014 | —0.001 |
| June | —0.024 | +0.016 | —0.004 |
| July | —0.004 | 0.000 | —0.002 |
| August | —0.001 | +0.009 | +0.004 |
| September | +0.011 | —0.007 | +0.002 |
| October | +0.056 | —0.009 | +0.024 |
| November | +0.052 | —0.013 | +0.019 |
| December | +0.003 | +0.014 | +0.008 |

These figures certainly indicate a remarkable uniformity of barometric pressure in this tropical region throughout the year, and tend to give confidence in the above conclusions.

## NOTES ON A FEEBLE EARTHQUAKE RECORDED AT WASHINGTON, D. C.

By C. F. MARVIN, Professor of Meteorology.

A new seismograph was installed at the Weather Bureau in the latter portion of February and on the morning of March 15, 1903, the first slight earthquake was recorded. The seismograph will be fully described elsewhere in the MONTHLY WEATHER REVIEW.

The instrument is so installed that the record gives the horizontal component of motion in the north and south directions. The tracing index magnifies the movement of the earth ten times. The free period of oscillation (complete) of the steady mass was eighteen seconds at the time of the earthquake.

The record was perfectly inscribed and showed all the recognized characteristics of these phenomena. Section *C* of fig. 1 is a reproduction of a portion of the record showing the earthquake. The short, transverse strokes are minute marks made on the record electrically by a standard clock. At the time of the earthquake the clock was 8.5 seconds, viz: 0.14 minute, fast. Each line of the original sheet contains the record for sixty minutes, hence, the transverse strokes forming a somewhat irregular line across the sheet are corresponding minutes of successive hours. Thus, on the margin one mark is checked 3:38 p. m., March 14, 1903. The corresponding mark on the adjacent line is 4:38 p. m., and so on.

From the record the earthquake is seen to consist of three distinct portions, namely: First, the preliminary tremors from *a* to *b*; second, the main or principal portion, from *b* to *c*; and finally the terminal portion, beginning at *c* and extending some distance beyond the section of the record here reproduced. All earthquake records of this kind exhibit these marked characteristics, especially when the vibrations have traveled to a great distance from the origin of the disturbance. Near the origin the preliminary tremors are of short duration or may be absent altogether. The times of the different phases of the record are as follows:

*March 15, 1903 (75th meridian time).*

| | H. | m. | s. |
|---|---|---|---|
| Preliminary tremors began | 9 | 29 | 0 |
| Duration of preliminary tremors | | 5 | 0 |
| Principal portion began | 9 | 34 | 0 |
| Duration of principal portion | | 2 | 36 |
| Beginning of terminal portion | 9 | 36 | 36 |
| End of tremors | 10 | 3 | 0 |
| Duration of terminal tremors | | 26 | 24 |
| Total duration of disturbance | | 34 | 0 |
| Strong vibrations at the maximum rate, comprising three full semivibrations, continued for a period of | | | 19 |
| Period of complete vibration at maximum | | | 12.8 |

Maximum double amplitude of earth movement, 0.31 millimeter.

The beginning of the principal portion is marked by several long-period oscillations of thirteen and one-half seconds, followed by shorter oscillations having about ten seconds period.